Pollution Prevention Practices: Determinants of Adoption and Effectiveness in Reducing Toxic Releases

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Total Quality Environmental Management

Application of quality management principles to environmental management

- Continuous improvement
- Defect/waste prevention, quality improvement, cost-reduction

- Meet/exceed consumer expectations for quality improvements and low costs

- 40-60% adoption rates among corporations by mid 1990’s

Implementation of TQEM

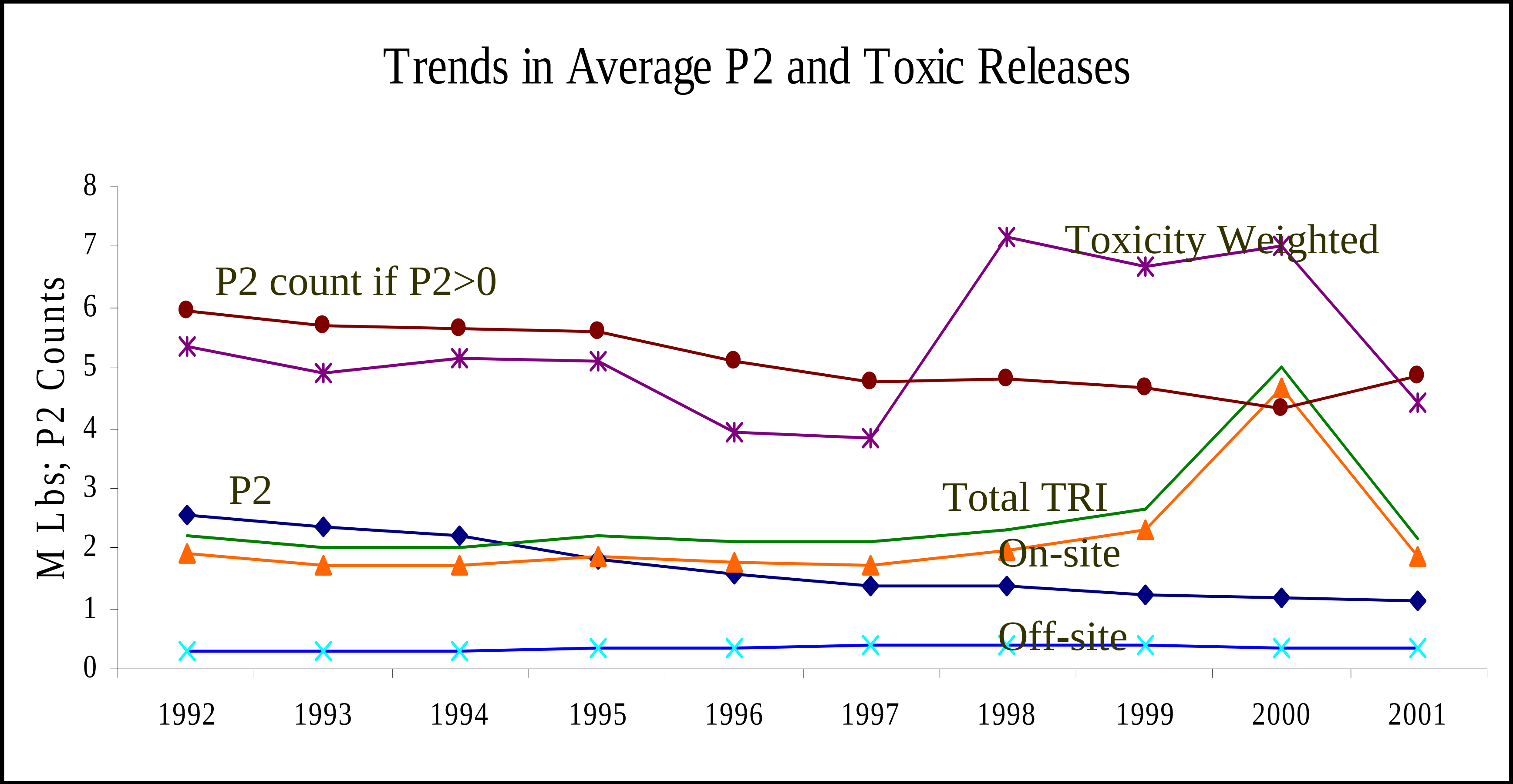
- Systems approach to underlying cause of problem
    - Defect prevention instead of detection
    - Pollution a form of defect/inefficiency
- Creation and utilization of firm-specific knowledge
    - – Cross functional teams identify practices, use of flow-charts, life-cycle analysis, full cost accounting
    - – Learning from other organizations
    - – Involvement of front-line employees in searching for improved and simplified work practices to improve quality
    - – Communication; information sharing among all hierarchical levels
    - – Employee training and team-based rewards
- Complementarities with Pollution Prevention

Research Objectives

- Determinants of the decision to adopt TQEM
  - Demand side pressures and supply side influences
- Determinants of the decision to adopt P2 techniques
  - Internal organizational changes: TQEM
  - External Pressures: Regulatory and Market
  - Technical capabilities
- Types of P2 techniques adopted by TQEM firms
  - Classify P2 practices according to
    - Functional characteristics (modifications to equipment, materials, procedures or other/customized)
    - Visibility to consumers
    - Efficiency enhancing/auxiliary cost savings
- Impact of P2 Adoption on Toxic Releases
    - Presence of lagged effects of P2
    - Path dependence in toxic releases

Data

- Sample of S&P 500 firms: Survey data on TQEM adoption (Investor Research Responsibility Center) for 1992-1996
- Sample of facilities of S&P 500 firms reporting to TRI (1991-2001)
- Toxic releases and pollution prevention activities- USEPA's TRI data
- Regulatory data from USEPA; Financial Data from Research Insight
- Pollution prevention practices: 8 broad categories adopted for each toxic chemical by each facility – aggregated for parent company
    - changes in operating practices, spill and leak prevention; modifications to equipment, processes, products or raw materials



Trends in Average P2 and Toxic Releases
M Lbs; P2 Counts
0
1
2
3
4
5
6
7
8
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
P2 count if P2>0
Toxicity Weighted
P2
Total TRI
On-site
Off-site

Research Question 1

What motivates the voluntary adoption of TQEM?

Key Findings

Internal motivations driving TQEM adoption rather than concerns about external stakeholders.

Demand Side (External Benefits)	Final Good Dummy Final * Market Share Final *Total Toxic Releases Superfund Sites, Penalties, Inspections
Demand Side (Internal Benefits)	Toxic Releases (+) *
Supply Side (Internal Capabilities/ Costs)	R&D Intensity (+)*** Sales (+)*** Number of Facilities (-) *** Market Share (+) ***
Industry Controls	Percent of Peer Firms Adopting TQEM (within 4 digit SIC) Industry Concentration (HH Index) SIC codes

Research Question 2

Does TQEM lead to the adoption of pollution prevention practices?

Do regulatory pressures encourage or discourage pollution prevention activities?

Measure of P2 Activities

- Sum of all New P2 activities adopted that year across all chemicals and facilities
- Count of Chemicals for which any P2 activity undertaken summed across chemicals and facilities
- Weighted Sum of New P2 across facilities with weights being facility’s share in the five-year lagged toxic releases of the parent company

Significant Motivators of P2

- TQEM
- Regulatory Pressure
  - Penalties, inspections, location in non-attainment counties have a positive impact on P2 but not on Weighted P2
    - Not motivating more pollution intensive facilities within the firm
  - Larger volume of HAP
  - Smaller threat of liabilities for Superfund Sites
- R&D Intensity
  - Stronger indirect effect by motivating TQEM than direct effect on P2
- Larger Number of Chemicals, Market Share of Sales
- Smaller toxic releases in the past
- Higher toxicity weighted releases in the past
- No effect
  - Market pressures from consumers and environmental groups, age of assets, sales

Key Findings on Motivators of P2

- TQEM does lead firms to adopt more P2 activities
- Firms and facilities within firms with high toxic releases face higher costs of P2 and adopt fewer P2
- Regulatory pressures, particularly, HAP motivate P2
- Technical capability an important determinant of P2 adoption

Research Question 3

Types of P2 Practices Responsive to TQEM

Channels through which TQEM affects operations

Types of P2 practices

- Four mutually exclusive functional attributes:
  - Physical changes in equipment
  - Change in materials usage
  - Change in operating procedures
  - Other customized modifications

- Two strategic classifications:
  - Visibility to consumers
  - Efficiency-enhancing

Classification of Pollution Prevention Practices

P2 Activities	Equipment	Material	Procedural	Efficiency	Consumers
Spill and Leak Prevention					
31 Improved storage or stacking procedures			X	X	
32 Improved procedures for loading, unloading, and transfer operations			X	X	
33 Installed overflow alarms or automatic shut-off valves	X			X	
36 Implemented inspection or monitoring program of potential spill or leak sources			X	X	
39 Other changes made in spill and leak prevention				X	
Process Modifications					
51 Instituted re-circulation within a process	X			X	
52 Modified equipment, layout, or piping	X				
58 Other process modifications made					
Product Modifications					
81 Changed product specifications					X
82 Modified design or composition of product		X			X

- 42 such categories of practices

Empirical Analysis

- Dependent variable
  - Number of P2 practices of a specific category adopted
- Explanatory variables
  - TQEM
  - TQEM * attributes (with the unclassified category as default)
  - Number of Chemicals
  - Cumulative $P2_{t-1}$
  - Total Lagge $P2_{t-1}$
  - Practice fixed effects
  - Firm fixed effects
  - Time fixed effects
- Five year panel data (1992-96)

Motivators of P2 and Types of Practices

- TQEM has a significant effect in motivating practices with
  - Unclassified/Customized attributes
  - Procedural Modifications
  - One of the above + Visible to consumers or Efficiency enhancing features
- Stimulus from recent experience with P2 practices
  - Number of P2 practices of all types adopted last year
- Diminishing returns to P2 adoption
  - Number of all P2 practices adopted since 1991

Simulation –Effect of Delaying TQEM Adoption by One Year

SIC Code and Industry Name		Mean % Change in Pollution Prevention Counts due to TQEM
13	Oil & Gas Extraction	14.2
20	Food and Kindred Products	13.6
21	Tobacco Products	14.0
26	Paper & Allied Products	12.0
28	Chemicals & Allied Products	20.1
29	Petroleum Refining & Related Industries	27.7
32	Stone, Clay, Glass, & Concrete Products	17.9
33	Primary Metal Industries	19.2
34	Fabricated Metal Products	10.8
35	Ind. & Comm Machinery & Computer Equip.	10.0
36	Electronic & Other Electrical Equipment	18.9
37	Transport Equipment	15.5
48	Communication	19.4
All Industries		16.1

Key Findings

Impact of TQEM on different pollution prevention activities is not uniform.

TQEM is more likely to

lead to adoption of non-generic P2 practices and firm-specific changes in operating procedures

rather than to

off-the-shelf modifications in materials and equipment

– Enhances P2 in industries with operations that are more dependent on procedures and customized practices

Research Question 4

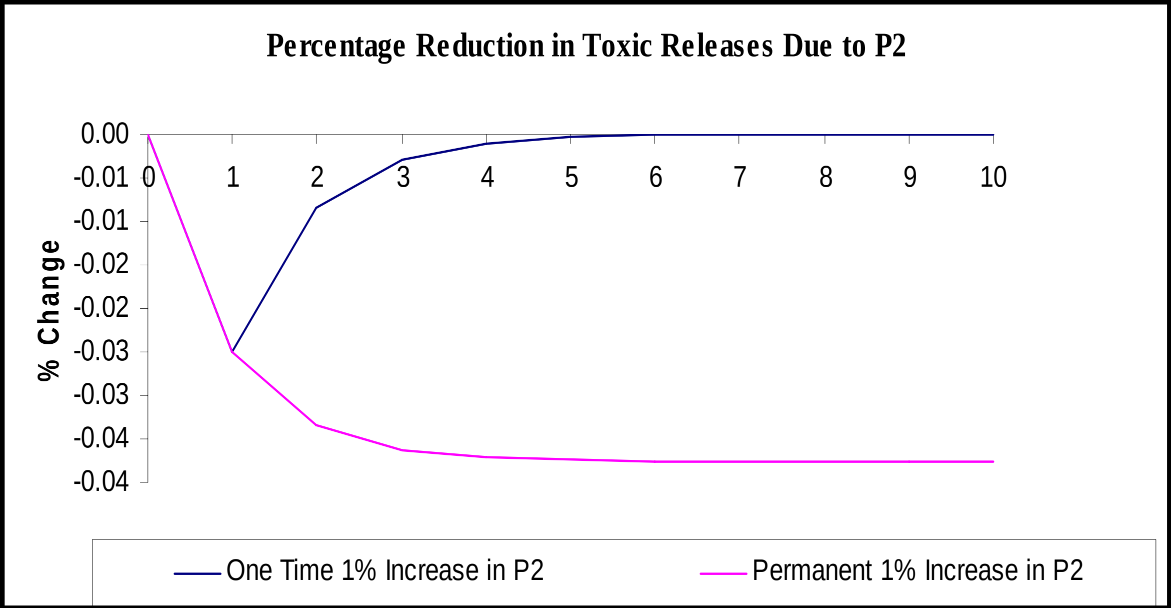
What is the impact of P2 adoption on toxic releases?

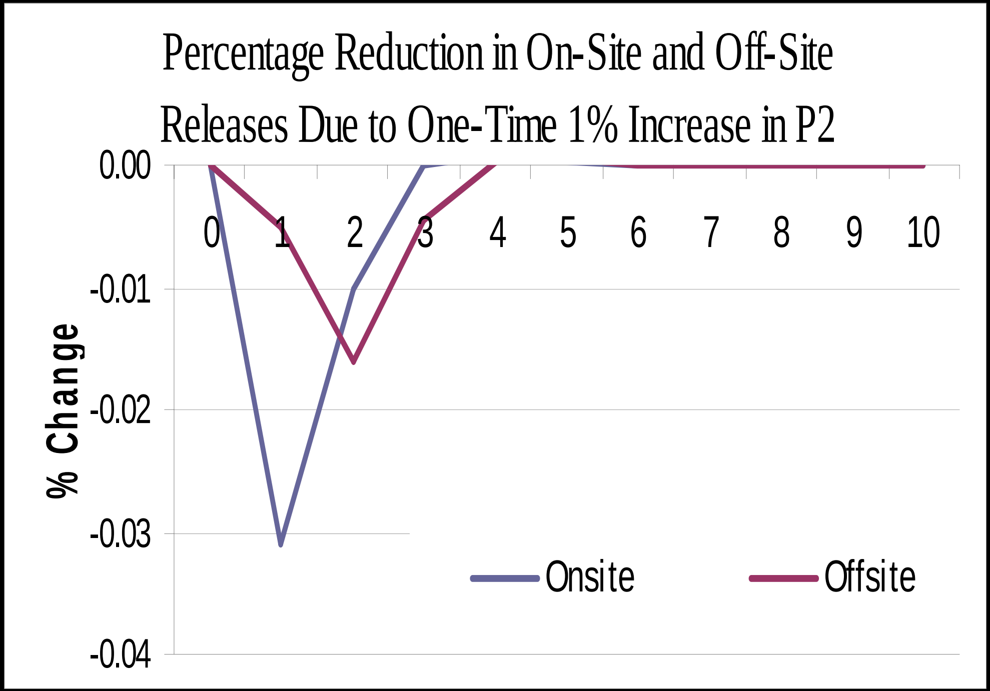
To what extent are toxic releases affected by past activities, current regulatory and public pressures?

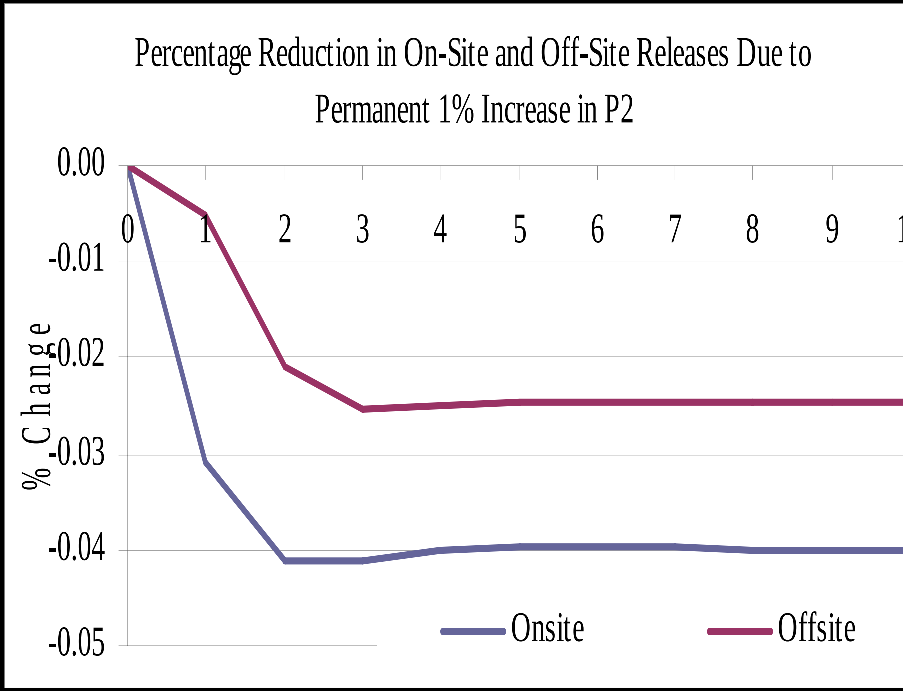
Key Determinants of Toxic Releases

- Previous year’s toxic releases (+)
- Previous year’s count of New P2 adopted (-)
  - Impact stronger on on-site discharges than on off-site disposal
  - Both direct and declining indirect impact on future toxic releases
- Previous year’s toxicity weighted releases (-)
- Location of facility in high income county (-)
- No impact of
  - contemporaneous P2 and earlier lags of P2 and toxic releases
  - regulatory and other locational pressures

Simulated Impact of a P2 Shock on Toxic Releases







Summary of Findings

- Voluntary environmental management efforts by firms do lead to environmentally friendly P2 innovations
- Trend towards P2 adoption diminishing over time
- Short term learning effect from past P2 adoption but longer term diminishing effect on P2 adoption
- P2 adoption reduces toxic releases with a 1 year lag but effect is transitory

Policy Needs to Promote Prevention of Toxic Releases

- Targeted public policy efforts to promote TQEM
  - In the form of technical assistance: lower costs of adoption
    - By firms in certain industries (e.g. chemical and petroleum)
    - For smaller, less technically innovative firms
- Regulatory pressures for environmental improvement
  - Targeted regulatory threat towards toxic pollutants (e.g HAP regulations)
- Emphasize concerns for toxicity of pollutants
  - To stimulate public and regulatory pressure for reduction

Conclusions

- Need to supplement voluntary incentives for P2 and toxic release reduction with regulatory stimulus
  - Adoption of P2 and current policies for toxic release reduction may not lead to large reductions in toxic releases
  - Doubling of P2 adoption would reduce releases by 4%
- Toxic release reduction is path and technology dependent
  - Need for regulatory, flexible stimulus to supplement voluntary incentives for adopting P2 and reducing toxic releases
- Future Research:
  - Type of P2 that are more environmentally effective
  - Effectiveness of P2 at chemical specific level